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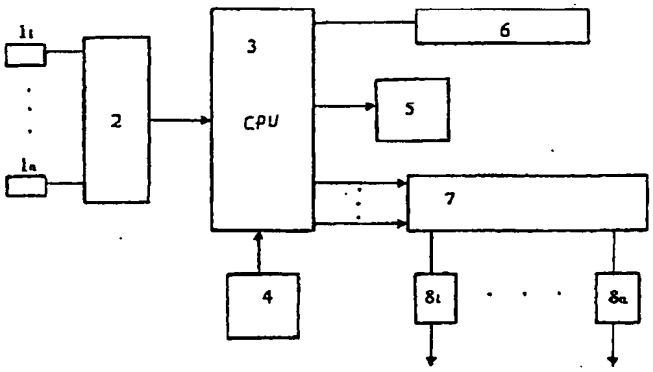
(54) Title: ELECTRICAL ENERGY METER



(57) Abstract: The electrical energy meter with energy prepayment, it is intended to simultaneous service of the customers number. The meter includes a reader (4) of information from the smart card, a display (5), interface (6), the microprocessor (3) for a calculation of consumed energy and performed payments and for control by the functional elements, a multiplexer (2) in the circuit between the sensors (1_1-1_a) of the current parameters (according to a customers number) and the microprocessor, to output of which a command unit (7) is connected; the last is coupled with a relay bank (8_1-8_a) for switching off an according customer in the case reaching of preset consumption of electrical energy. In the case of the customers being spaced at a substantial distance from each other the meter is made with placement in the central cabinet (16) and personal cabinets (17_1-17_a) for each customer; the last has corresponding elements of coupling between the cabinets, feed of signals for customers switching-off and feed of alarm signal during tampering with cabinets.

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Disclosure of the Invention

A meter is offered which provides a solution to the task defined above and is intended for reliable simultaneous serving of many customers with the possibility of installing one device in a condominium doorway, house or settlement (*moshav, aul,* etc.).

Like prior art meters of this class, the proposed meter has a unit to read the information off the smart card, information display (showing among other things the currently available credit for buying electricity), interface to transmit to the display the information about electric current parameter fluctuations over a definite interval of time, a processor which records the amount of expended electricity, calculates payments, the available credit, and controls the meter's functional elements (components).

But unlike prior art meters, this meter has a multiplexer, with its input connected to the output of the group of current parameters sensors (at least one sensor for each customer) and its output connected to the general processor which receives the information about the parameters of the current each customer consumes in time. The said meter also has a command unit (signaling device) connected to the processor's outputs to transmit the processor's commands to the group of relays (at least one relay for each customer) and disconnect the customer who has used up the credit for a definite amount of electricity from the external line.

The described solution reduces the cost of the meter per customer which makes a wider use of such meters financially feasible.

To increase the accuracy of measuring the current parameters, each sensor can be equipped with a current transformer, and an analog-to-digital converter can be connected between the multiplexer and the processor and switched on at intervals of time sufficient to ensure the preset class of accuracy by recording the parameters of the current in time.

If it is impossible and/or inexpedient to employ an analog-to-digital converter which can be switched on frequently enough to ensure the preset accuracy of recording the current parameters, the sensor is equipped with a

current transformer, a linear pulser and a pulse counter, with the latter connected to the processor via a multiplexer.

To optimize the device, the current parameter sensor can be equipped with a shunt (instead of the transformer) coupled with the linear pulser whereas

- the output of the pulser is coupled with the pulse counter via an optical circuit separator (optical couple);
- the pulse counter's output is coupled with the processor via the multiplexer.

Such solution ensures greater operation safety.

To ensure protection against fraudulent connection and prevent any tampering, all the components of the meter are housed in one cabinet (box) and secured against outside access by separate cables laid on to the individually controlled premises of the customer.

In the case of customers being spaced at a substantial distance from each other (for instance, in rural settlements) when the connection of each customer to the meter by a separate cable is not expedient financially,

- the meters are made with placement in the central cabinet and in personal cabinets (one for each customer),
- the central cabinet houses the components serving all customers and a transmitter-receiver,
- personal cabinets (each containing current parameter sensors, relays and devices to ensure coupling between personal and central cabinets) are located close to each customer in a place barring easy access.

In the latter case, to prevent electricity theft by cutting into the power network in the section between the central and personal cabinets, in addition to the personal cabinet sensors the current parameter sensor is also placed on the input of the central cabinet. The meter has an alarm device for customer cutoff in case the difference between the amount of energy entering said meter and the amount of energy fixed by the sensors in the personal cabinets over the same period of time exceeds the permissible value.

Each of the cabinets described herein has a device for giving a sound signal, disconnecting the customer from the power network and transmitting the alarm signal to the power supplier if a cabinet is opened (tampered with) by unauthorized persons, and/or a meter (or a section of the network controlled by a meter) is broken into.

A solution to the task of avoiding excessive energy losses (if customers are spaced at a substantial distance from each other) is offered by the method described below which envisages the following steps:

- measuring the amount of electrical energy which entered the meter over a fixed period of time
- determining the total amount of energy fixed by the sensors in the personal cabinets over the same period of time,
- determining real losses (the difference between the amount of electrical energy which entered the meter over some interval of time and total amount of energy fixed (recorded) by the sensors in personal cabinets over the same period of time),
- comparing the determined real losses with the value (level) of permissible losses,
- disconnecting the customer and giving an alarm signal if real losses exceed the permissible level.

A comparative analysis of this meter and prior art solutions of similar purpose shows that the proposed meter has novelty and inventive step, industrially applicable - all of which makes the proposed solution worthy of legal protection by a patent.

Brief Description of the Drawings

The substance of the invention is illustrated by the attached drawings, in particular

Fig.1 - block diagram of the base variant of the proposed meter.

Fig.2 - block diagram of the meter, with analog-to-digital converter and current transformers of the current parameter sensors.

Fig. 3 - fragment of the block diagram of the meter with current transformer of sensor, linear pulser and pulse counter.

Fig.4 - fragment of the block diagram with the shunt of the current parameter sensor, linear pulser, optical circuit separator, and pulse counter.

Fig.5 - diagram of the positioning of the meter's main parts when the customers are spaced widely from each other.

Description of the Preferred Embodiments

The meter in its base variant (Fig.1) has sensors 1 of the electric current parameters (voltage and current) changing in time. There is at least one sensor for each connected customer (n - the total quantity of sensors).

The outputs of sensors $1_1 \div 1_n$ are connected to the inputs of multiplexer 2, its outputs coupled to microprocessor 3 for consecutive reading by said microprocessor of sensor indications (indications of binary counters whose number is equal to the number of customers) and recording the results in non-volatile memory (capable of storing the latest indications even in the event power is cut off).

Reader 4, which reads off the smart card the amount of power pre-paid for by each customer, is connected to said microprocessor 3 (CPU).

Display 5, also connected to said microprocessor 3, gives information, specifically on the credit each customer still has (corresponding to the amount of electricity in kWh each customer can receive).

Further, interface 6 is connected to said microprocessor 3 to transmit information to external unit upon request.

Finally, general command unit 7 is connected to microprocessor 3; said command unit being essentially a decoder from binary to position code and an amplifier ensuring output current sufficient for the normal functioning of the relay (or semi-conductor switch) 8 connected to the circuit of the amplifier, said relay (or semi-conductor switch) meant to connect to the power network each customer who has credit for electricity and disconnect from the power network each customer who has used up his credit for the

preset amount of electricity. All in all, the meter has (n) relays or switches $8_1 \div 8_n$ for each customer using the meter.

For greater accuracy of metering electric current parameters, each sensor can be equipped with current transformer 9 and amplifier 10 (Fig.2), and analog-to-digital converter (ADC) 11 can be switched on between multiplexer 2 and microprocessor 3, with the switch-on frequency ensuring the preset accuracy of recording current parameters in time.

If it is impossible or inexpedient to use analog-to-digital converter which can be switched frequently enough to record current parameters with a preset accuracy, the sensor can be connected to current transformer 9 (Fig.3), linear pulser 12 and pulse counter 13, with the latter connected to microprocessor 3 via multiplexer.

Instead of current transformer, shunt 14 (Fig.4) coupled with linear pulser 12 can be employed: in this case the output of the pulser is coupled with pulse counter 13 via optical circuit separator 15 (optical couple), with the output of said counter 13 coupled with microprocessor 3 via multiplexer.

Said pulser 12, one for each customer, is intended to transform the digits, in which incoming electricity is counted, into consecutive pulses of set duration coming at a rate proportional to the active power values (corresponding to incoming electrical energy).

To ensure protection against fraudulent connection and/or prevent any tampering, all the components of the meter are housed in one cabinet (secured against outside access): with separate cables laid on to the individually controlled premises of the customer.

In the case of customers being spaced at a substantial distance from each other (in particular, in rural areas) when separate cable connection of each customer to the meter is financially unfeasible, the meter (Fig.5)

- is made with placement in the central cabinet 16 and in personal cabinets $17_1 \div 17n$ (one for each customer),
- the central cabinet houses the components serving all customers (specifically functional elements 1, 3, 4, 5) and transmitter-receiver 18,

- personal cabinets $17_1 \div 17n$ are located close to each customer $19_1 \div 19n$ in a place barring easy access; said personal cabinets house sensors $1_1 \div 1n$ of current parameters, specifically elements $14_1 \div 14n$, $12_1 \div 12n$, $13_1 \div 13n$, relays $8_1 \div 8n$ and devices $18_1 \div 18n$ for providing of link (communication) between personal and central cabinets.

In the latter case, to prevent electricity theft by cutting into the power network in the section between the central and personal cabinets, in addition to the personal cabinet sensors the current parameter sensor is also placed on the input of the central cabinet. The meter has an alarm device for customer cut off in case the difference between the amount of energy entering the meter and the amount of electrical energy fixed by the sensors in the personal cabinets over the same period of time exceeds the preset value.

Each of the cabinets described herein has a device for giving a sound signal, disconnecting the customer from the power network and transmitting the alarm signal to the power supplier if a cabinet is opened (tampered with) by unauthorized persons, and meters (or a section of the network controlled by a meter) is broken into.

The meter operates as follows:

To ensure an uninterrupted supply of electricity, every customer must pre-pay for electricity in a bank, which writes the sum of the electricity credit into his personal smart card. The customer gets electricity upon inserting the smart card into the meter.

The microprocessor uses the receiving unit to record in the appropriate memory cell the sum pre-paid by the customer and his tariff rate. After that the microprocessor activates the relay (or the semi-conductor switch, which is its non-contact equivalent) and thus opens power supply to the customer who has made the pre-payment.

During the operation of the meter, the microprocessor, jointly with multiplexer, consecutively reads data off all the sensors which transmit the electric current parameters in analog form, in particular to analog-to-digital

converter, which converts the information into digital form and transmits said parameters to microprocessor in digital form.

The reading cycle is repeated with a switch-on frequency necessary to ensure the preset class of accuracy. It is a frequency which makes it possible for the microprocessor to calculate the amount of electricity received by each customer with the required accuracy and transmit to his cell the data on the parameters of the current received, the amount of electricity expended, the amount of the credit used up and available, taking account of the time tariffs.

If a customer has used up all sum of his pre-payment (and has not made another one), the microprocessor uses the command unit (and the appropriate relay) to disconnect this customer from the power network (the system of electricity power service).

The customer can at any moment verify how much credit is still available to him by inserting the smart card into the meter: after this action the microprocessor transfers to the display the amount of the available credit stored in the memory cell of this customer.

In another embodiment of the meter, the sensor of the current parameters equipped with transformer (or shunt), linear pulser and pulse counter (the pulse number is proportional to the amount of incoming electrical energy), transmits the information about the electric current parameters and the amount of the fixed energy to the microprocessor via multiplexer.

To avoid conductive coupling of the microprocessor and power network, the pulses from each pulser 12 go to pulse counter 13 (binary) via the optical couple (in the shunt embodiment of the meter), the microprocessor reading off said counter at preset intervals of time. After each reading counter 13 is caused to go to zero to avoid overflowing.

The results of readings are summed up in the memory cell of the customer and compared to the amount of the electricity paid for.

In this embodiment, information can be transmitted with low frequency. It allows to transmit information from sensors to microprocessor via multiplexer, using transmitter-receivers even if the meter components are

placed in different (central and personal for each customer) cabinets located at a considerable distance from one another.

However, this kind of placement the meter's components with respect to the customer creates auspicious conditions for fraudulent connection to the power network in the section between the main and personal (individual) cabinets.

To prevent fraudulent connection (theft of electricity), special devices installed in cabinets send sound signals, customer cutoff signal and alarm signal for the power supplier in the event a cabinet housing a meter has been broken into or tampered with by unauthorized persons or if a section of the power network controlled by a meter has been fraudulently penetrated.

The said function of preventing fraudulent use of electricity is performed by transmitting to microprocessor the information about the amount of electricity that has entered the meter input and the total amount of electricity recorded by the sensors in personal cabinets over a definite period of time and subsequently comparing these two values. If electricity has been stolen, the difference between said measured values will be above the permissible level, which will activate the abovesaid system.

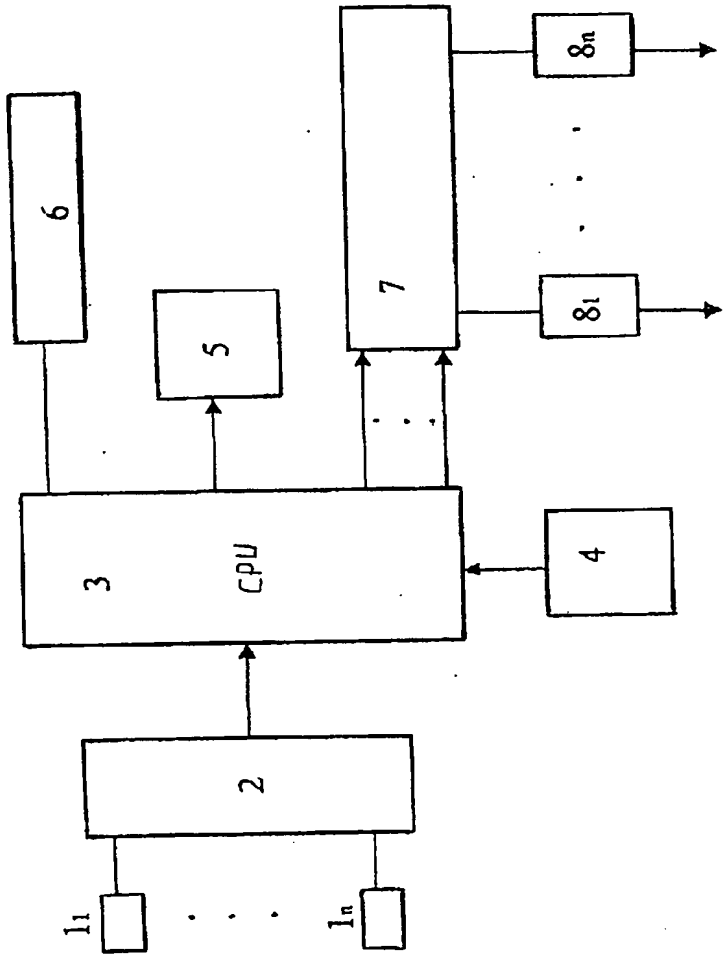

Fig.1

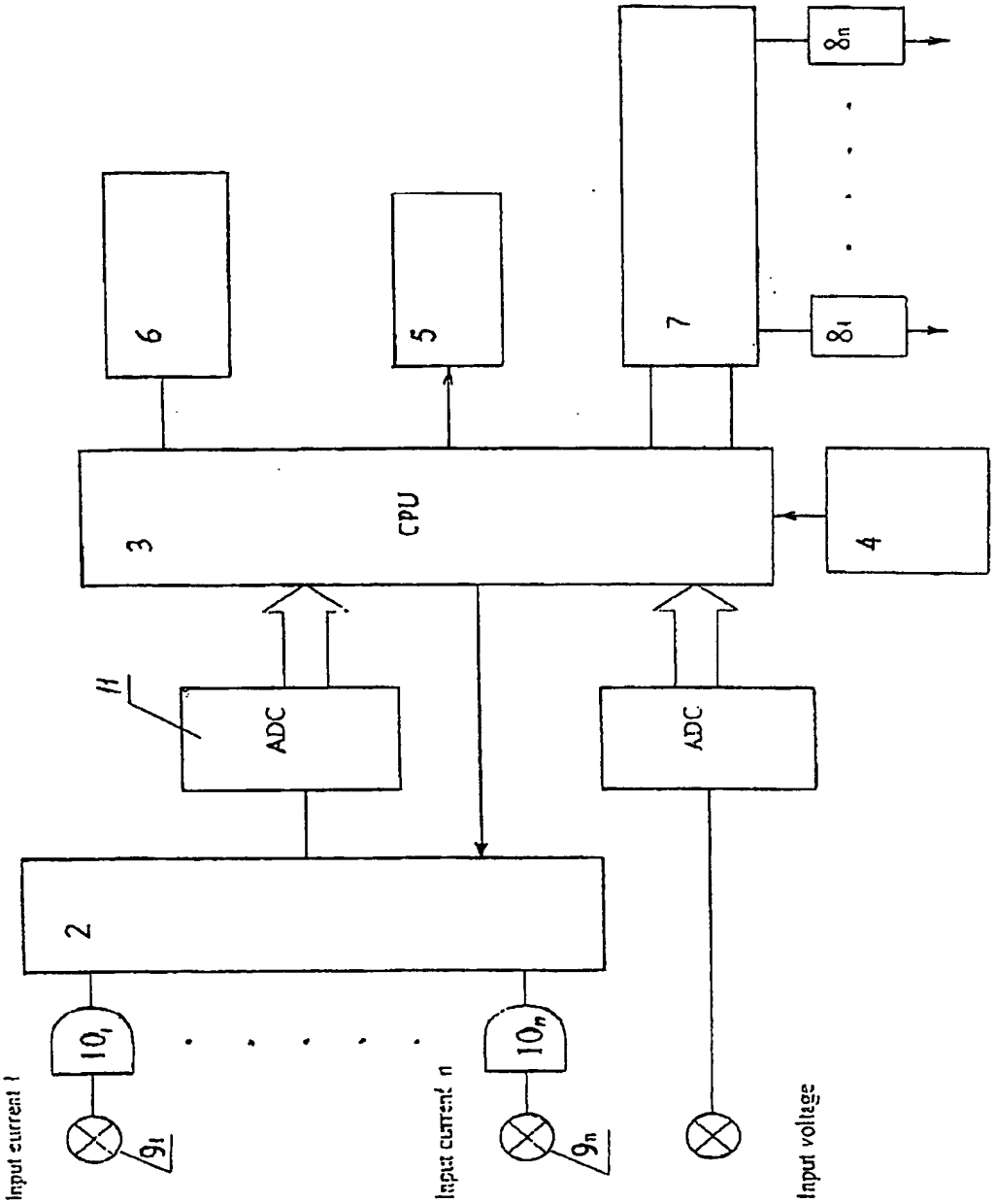
6
5
7
8n
8i
3
CPU
4
11
ADC
ADC
2
10i
10n
9i
9n
Input current i
Input current n
Input voltage

Fig. 2

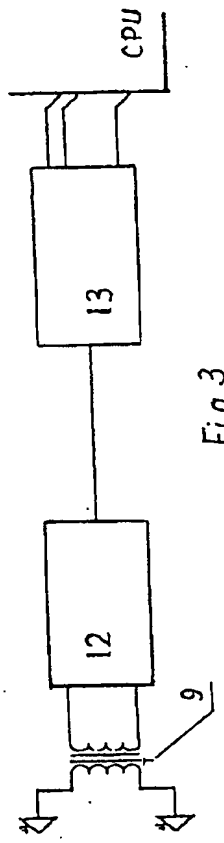

Fig.3

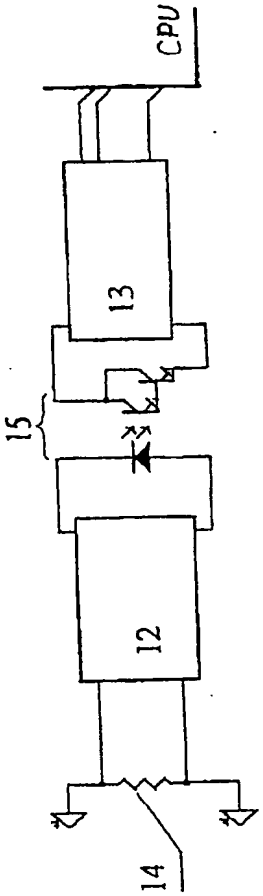

Fig.4

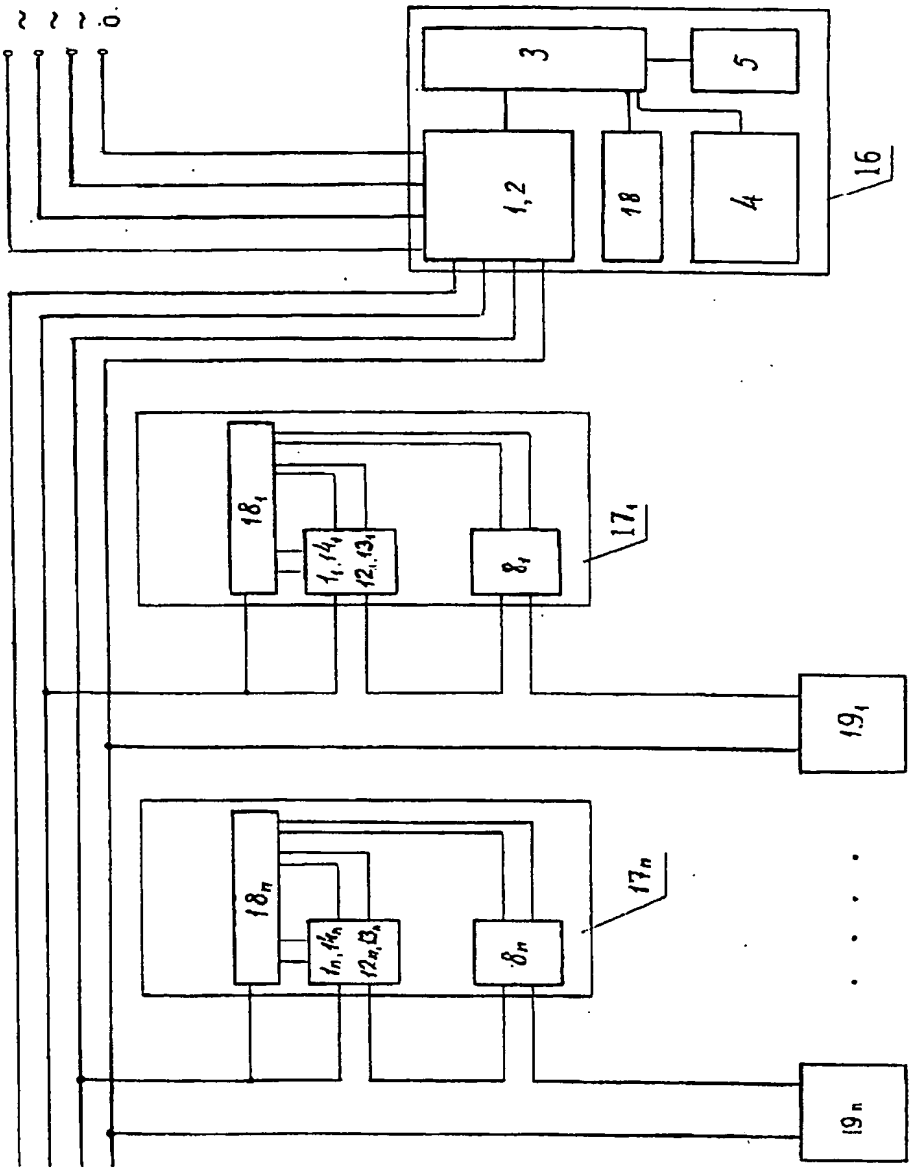
3
5
1,2
18
4
16
18₁
1₁,14₁
12₁,13₁
8₁
17₁
19₁
18ₙ
1ₙ,14ₙ
12ₙ,13ₙ
8ₙ
17ₙ
19ₙ

Fig. 5